FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
0365-0525P	
U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	
10/088730	

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI00/00542	June 15, 2000	June 17, 1999

TITLE OF INVENTION

METHOD AND APPARATUS FOR MEASURING WATER CONTENT

***APPLICANT(S) FOR DO/EO/US**

STORMBOM, Lars; LYYRA, Matti; LEPPANEN, Jukka

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau). WO 00/79256
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98, Form PTO-1449(s), and International Search Report (PCT/ISA/210) with 7 cited document(s).
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
    1.) PCT Substitute Claims Letter w/ PCT/IPEA/409 and amended claims
    2.) One (1) sheet of Formal Drawings

531 Rec'd PCT/ 17 DEC 2001

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/009730	PCT/FI00/00542	0365-0525P

21. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO..... **$1,040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO..... **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)..... **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)..... **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1040.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	14 - 20 =	0	X **$18.00**	$	0
Independent Claims	2 - 3 =	0	X **$84.00**	$	0
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		None	+ **$280.00**	$	0
TOTAL OF ABOVE CALCULATIONS =				$	1170.00
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$	0
SUBTOTAL =				$	1170.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	0
TOTAL NATIONAL FEE =				$	1170.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	0
TOTAL FEES ENCLOSED =				$	1170.00
			Amount to be: refunded	$	
			charged	$	

a. ☒ A check in the amount of $ **1170.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:
Birch, Stewart, Kolasch & Birch, LLP or Customer No. 2292
P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

Date: Decmeber 17, 2001

By _____
James M. Slattery, #28,380

/cqc

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant:	STORMBOM, Lars et al.		
Int'l. Appl. No.:	PCT/FI00/00542		
Appl. No.:	New	Group:	
Filed:	December 17, 2001	Examiner:	
For:	METHOD AND APPARATUS FOR MEASURING WATER CONTENT		

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

December 17, 2001

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/FI00/00542 which has an International filing date of June 15, 2000, which designated the United States of America and was published in English.--

IN THE CLAIMS:

Please amend the claims as follows:

3. (Amended) Method according to claim 1, characterized in that said relative water content measurement is carried out using a capacitive sensor.

4. (Amended) Method according to claim 1, characterized in that changes in the results of water content measurement due to aging of the liquid are compensated for by virtue of using only the most recent data of the measurement history for the compensation for changes in the response of the measurement system.

5. (Amended) Method according to claim 1, characterized in that the aging of said liquid, advantageously oil, is indicated on the basis of changes in the value of ε_0.

6. (Amended) Method according to claim 1, characterized in that, in the measurement of relative water content, an auxiliary medium is used for absorbing thereto the water contained in the liquid under measurement.

8. (Amended) Method according to claim 5, characterized in that the water content of said auxiliary medium is determined by way of measuring its dielectric coefficient.

11. (Amended) Apparatus according to claim 9, characterized in that one electrode (6) of the sensor pair adapted to perform the measurement of dielectric coefficient also forms a part of the measurement electrode pair (1,6) adapted to perform the measurement of the relative water content.

14. (Amended) Apparatus according to claim 12, characterized in that the apparatus contains means adapted to measure the dielectric coefficient of said auxiliary medium whereupon the relative water content of said auxiliary medium can be determined.

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

The claims have been amended to delete multiple dependencies and to place the application into better form for examination. Entry of the above amendments is earnestly solicited. An early and favorable first action on the merits is earnestly solicited.

Attached hereto is a marked-up copy of the changes made to the application by this Amendment.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By _____
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Attachment: VERSION WITH MARKINGS TO SHOW CHANGES MADE

VERSION WITH MARKINGS TO SHOW CHANGES MADE

The claims have been amended as follows:

3. (Amended) Method according to claim 1[or 2], characterized in that said relative water content measurement is carried out using a capacitive sensor.

4. (Amended) Method according to [any one of foregoing claims]claim 1, characterized in that changes in the results of water content measurement due to aging of the liquid are compensated for by virtue of using only the most recent data of the measurement history for the compensation for changes in the response of the measurement system.

5. (Amended) Method according to [any one of foregoing claims]claim 1, characterized in that the aging of said liquid, advantageously oil, is indicated on the basis of changes in the value of ε_0.

6. (Amended) Method according to [any one of foregoing claims]claim 1, characterized in that, in the measurement of relative water content, an auxiliary medium is used for absorbing thereto the water contained in the liquid under measurement.

8. (Amended) Method according to claim 5[or 6], characterized in that the water content of said auxiliary medium is determined by way of measuring its dielectric coefficient.

11. (Amended) Apparatus according to claim 9[or 10], characterized in that one electrode (6) of the sensor pair adapted to perform the measurement of dielectric coefficient also forms a part of the measurement electrode pair (1,6) adapted to perform the measurement of the relative water content.

14. (Amended) Apparatus according to claim 12[or 13], characterized in that the apparatus contains means adapted to measure the dielectric coefficient of said auxiliary medium whereupon the relative water content of said auxiliary medium can be determined.

METHOD AND APPARATUS FOR MEASURING WATER CONTENT

The invention relates to a method according to the preamble of claim 1 for measuring the water content of a liquid.

The invention also relates to an apparatus for measuring the water content of a liquid.

US Pat. No. 5,331,287 describes a sensor, wherein interdigitated electrodes (finger electrodes) are coated with a conducting polymer. Water contained in the oil hydrates the polymer and thus modifies its conductivity. Also detects possible acids by way of protonation.

US Pat. No. 5,642,098 discloses a ring oscillator circuit, wherein electrical properties of the oil are measured with a number of measurement heads which measure the same parameter.

US Pat. No. 5,644,239 measures the electrical conductivity of a liquid (oil) at two elevated temperatures. The technique may be complemented with a possible optical measurement of oil opacity. A "figure of quality" may then be computed for the oil from these parameters.

US Pat. No. 5,656,767 describes a sensor system for measuring the change of an electrical parameter value (e.g., capacitance) in oil as a function of time. The same oil at a clean (dry) state may be used as a reference value. The same technique may be varied in multiple ways, e.g., by heating the oil sample.

Conventional techniques are handicapped in many aspects. Common methods for sensing absolute water volume content over the entire range of 0-100 % are the measurement of the dielectric coefficient and measurement of IR absorption. Both of these methods have in common that they require a zeroing step of the measurement system, whereby the reading must be reset to zero water content when the sensor is

brought to measure an entirely dry (water-free) liquid. This step can be accomplished as a discrete zeroing operation or by using a sample of entirely dry oil in the sensor as a reference.

An additional complication arises therefrom that such a zero setting is typically dependent on the temperature.

Also other factors besides the water content may affect the zero-value with the aging of the liquid.

Methods measuring the absolute water content are favored at high water contents (in the order of several per cent).

At lower water contents, problems generally arise from the marginal detection threshold and offset uncertainty (error of zero setting).

A relative value (aw) measurement method gives information on the water content value in relation to that of a fully saturated situation. However, a conversion to the volume percentage value of absolute water content remains undefined unless a conversion factor for the liquid being measured is known. The aw measurement method is suitable for use at low water content levels (nonsaturated and not emulsified), whereby the measurement has a sufficiently high sensitivity. Moreover, the method is free from zeroing problems.

It is an object of the present invention to overcome the drawbacks of the above-described techniques and to provide an entirely novel type of method and apparatus for measuring the water content of a liquid.

The goal of the invention is achieved by way of measuring the water content of the oil/liquid using two different methods simultaneously, whereby the measurement technique is based on an absolute value measurement method complemented with a relative value measurement method.

More specifically, the method according to the invention is characterized by what is stated in the characterizing part of claim 1.

Furthermore, the apparatus according to the method is characterized by what is stated in the characterizing part of claim 9.

The invention offers significant benefits.

The combination of an absolute value measurement method with a relative value measurement method (aw-type of measurement) makes it possible to eliminate the need for a zeroing step in the absolute value measurement.

By way of performing a sequence of rapidly repeated measurements at different temperatures, it is also possible to eliminate errors caused by temperature variations.

In the following, the invention will be examined in more detail by means of exemplifying embodiments illustrated in the appended drawings, in which:

FIG. 1 shows a top view of an embodiment of an electrode structure according to the invention; and

FIG. 2 shows a sectional view of the sensor structure of FIG. 1 along line A-A.

As shown in FIGS. 1 and 2, the embodiment according to the invention can be implemented using a structure, wherein onto the surface of a substrate 4 is formed a combination of three electrodes. The surface of the substrate 4 has directly deposited thereon a pair 3 of bottom electrodes formed by electrodes 5 and 6. In the illustrated case, the electrodes are shaped into finger electrodes, more specifically disposed as interdigitated electrodes, whereby the interelectrode surface is maximized by using an electrode structure having the finger electrodes displaced between each other. The length of the adjacent edges of the interdigitated electrodes 5 and 6 is equivalent to

the area of superimposed electrodes in a planar capacitor. The width and interelectrode gap of the electrodes 5 and 6 typically are in the range of 5 to 500 micrometers. In addition to its interdigitated finger electrode portion, the electrode 6 has a planar area 7. Furthermore, the electrodes 5 and 6 include contact pad areas C1 and C2 for connection of the electrodes to measurement means. Onto the bottom electrode pair 3 is deposited a polymer layer 2 having a thickness of 0.5-5 micrometer typical. The area of the polymer layer 2 may also be extended over the interdigitated finger electrode structure 5 and 6, whereby it also functions as a passivation layer and reduces the effect of conducting particles contained in the liquid sample on the measurement result. Onto the polymer layer 2 is deposited a water-permeable top electrode 1 with a contact pad area C3 for external connections. The top electrode 1 is aligned above the rectangular solid area 7 of the electrode 6 in order to form a planar capacitor structure.

The structure illustrated in FIGS. 1 and 2 is utilized as follows. The dielectric coefficient of the liquid under measurement is measured over the contacts C1 and C2 of the electrodes 5 and 6. Respectively, the relative value measurement is performed over the electrodes 6 and 1, that is from the contacts C1 and C3.

Advantageously, the liquid whose water content is measured is oil, but the water content measurement according to the invention may also be performed on other liquids such as a hydraulic fluid, gasoline or a coolant as well.

According to the invention, the measurement of the activity of water can be carried out as follows.

Firstly, it must be noted that the water activity measurement is only an exemplifying embodiment of the relative value measurement technique according to the invention.

As shown in FIGS. 1 and 2, the sensor may comprise a polymer layer 2 deposited between two electrodes as an element, whose absorbency of water is a function of the activity of water in its immediate environment. Typically, such sensors are used

as relative humidity transducers, for example. This type of measurement method is characterized in that the measurement result indicates the degree of water activity, that is:

$$aw = F(ppm/ppm_s(T)), \quad (1)$$

where

ppm = volumetric proportion of water in solution$\times 10^6$

ppm_s = volumetric proportion of water in saturated solution$\times 10^6$

The function F may for example be assumed to have a linear nature, whereby:

$$aw = ppm/ppm_s(T) \quad (2)$$

The value of aw varies from 0 (entirely dry liquid) to 1 (entirely saturated water solution).

Hence, a mere water activity measurement gives information on how close the situation is either to an emulsified state or a water-separation state. However, when the state of emulsification or water separation is reached, the value of water activity becomes very close to 1, whereby no information on the state of the liquid can be obtained. Nevertheless, the method can render at values of $aw < 0.9$ in a very sensitive manner such oil/liquid-independent information that, for example, is related to the lubrication properties of the measured sample.

At room temperature, the value of ppm_s may vary from 20 ppm for a basic oil having no additives to values above 10,000 ppm for lubrication oils rich with additives.

Next, the measurement technique of the dielectric coefficient is elucidated in more detail. The measurement of the dielectric coefficient is only one exemplifying

embodiment of the absolute-value concentration measurements possible within the scope of the invention.

In the measurement of the dielectric coefficient of a liquid , the sensor may be implemented either using the interdigitated electrode (finger-electrode) structure according to FIGS. 1 and 2 or, alternatively, formed into a coaxial pair of electrodes brought into contact with the liquid to be measured. The output signal of the sensor is dependent on both the dielectric coefficient and water content of the liquid under measurement:

$$\varepsilon_r = \varepsilon_0 + F(ppm) \quad (3)$$

where

ε_0 = dielectric coefficient of entirely dry liquid,

F(ppm) = a function dependent on the water content. Over a limited range of water content, the function may be assumed to be linear, that is:

$$\varepsilon_r = \varepsilon_0 + a \times ppm \quad (4)$$

where

a = constant independent of the liquid type.

An advantage of the dielectric coefficient measurement technique is that it covers the entire possible measurement range from 0 to 100 vol-% water. A disadvantage of the method is that its sensitivity at the low end of water content (where the greatest interest usually lies) is low and that the value of ε_0 must be known. Typically, the measurement system is calibrated using dehydrated oil as a standard.

If both of the above-described measurement techniques are employed simultaneously, a number of different calibration techniques can be used for a given liquid.

If the liquid is known by the value of its $ppm_s(T)$, the following approach is possible:

First, the values of aw and ε_r are measured simultaneously. If aw is less than 1, formulas 2 and 4 may be assumed to be valid.

Then, the combination of formulas 2 and 4 can be solved for ε_0 and ppm. It is also possible to estimate the value of $ppm_s(T)$ if the type of the liquid is known, whereby the result thus obtained, however, remains slightly more inaccurate.

If the value of $ppm_s(T)$ of the liquid is unknown, the following procedure can be carried out:

The sensor output is measured at two (unknown) water content values. If the value of aw is smaller than 1 in both cases, an equation group of four equations and four unknown variables is obtained, which means the equations can be solved in unique manner. Assigning subindices 1 and 2 for the measurement results of the two sessions, respectively, the following formula can be written:

$$\varepsilon_0 = (aw_2 \times \varepsilon_{r1} - aw_1 \times \varepsilon_{r2})/(aw_2 - aw_1) \qquad (5)$$

This procedure may also be arranged to take place automatically during the continuous function of the measurement apparatus if the water content of the liquid under measurement varies.

If the measurement data is collected by more than two pairs of values, the unknown terms can be fitted to the data using, e.g., the least squares method.

The benefit of the latter technique is that possible changes in the values of ε_0 or $ppm_s(T)$ due to temperature variations or aging/soiling of the liquid can be compensated for. In fact, the changes detected in ε_0 serve as an indicator of aging in oil.

If the temperature of an oil sample or, respectively, of a sample flow, is changed so rapidly that the water content of the sample can be assumed to stay substantially unchanged, it is possible to determine the temperature dependence of the dielectric coefficient of an entirely dry liquid by way of measuring essentially simultaneously the ε_r and temperature of the liquid at at least two temperatures.

For example it can be assumed assuming that ε_0 is a linear function with temperature:

$$\varepsilon_r = b0 + b1 \times T + a \times ppm \qquad (6)$$

whereby the following formula can be formed

$$\varepsilon_r(T2) - \varepsilon_r(T2) = b1 \times (T2 - T1) \qquad (7)$$

wherefrom the coefficient b1 can be solved. Also in this case, it is possible to collect values at a greater number of temperatures and then fit the measurement results with the help of the least squares method. This technique gives a continuously reliable parameter estimate value for ε_0 as the temperature varies.

Also the temperature dependence of $ppm_s(T)$ can be determined simultaneously. Over a limited temperature range, a general assumption may be made as:

$$ppm_s(T) = c0 \times e^{(C1 \times T)} \qquad (8)$$

where

c0 = value of ppm_s at T = 0 °C

c1 = coefficient of temperature dependence.

Then, the value of c1 can be solved by way of measuring aw at at least two temperatures with the assumption that the water content of the liquid remains unchanged during the measurements:

$$c1 = LN(aw1/aw2)/(T2-T1) \quad (9)$$

Advantageously, these two determinations may be carried out simultaneously.

According to a preferred embodiment of the invention, the zeroing operation is performed automatically each time the measurement of aw gives a sufficiently low value. The lower the value of aw the more accurate the zeroing operation. The uncertainty of the method is associated with the value of $ppm_s(T)$ that is dependent on the type of liquid under measurement and thus can be obtained by an "intelligent guess".

According to another preferred embodiment of the invention, two samples of the liquid/oil having different water contents are taken. Then, the measurement system may intentionally be set to measure two samples of different water contents or, alternatively, gradual accumulation of data from the measured process is utilized, whereby the natural variation of water content in the monitored process is availed of. This approach also gives a value for $ppm_s(T)$ on the basis of which it is possible according to the invention to compute from the measured value of aw the correct value of ppm without resorting to an "intelligent guess".

If a continuous data collection from the monitored process is performed using simultaneously a sliding-window technique for "dumping" obsolete data, it is also possible to compensate for changes in both the value of ppm_s and ε_0 due to aging of the liquid/oil.

In the case that the process also is subjected to temperature changes, the temperature dependencies of ppm_e and ε_0 can also be resolved.

PCT/ FI 00/ 00542
24 -08- 2001

What is claimed is:

1. Method for measurement of water content of a liquid, in which method a property of the liquid is measured electrically for one parameter,

- the properties of the liquid are measured at least substantially simultaneously also by another electrical method, whereby the properties of the liquid are measured using both a relative-value measurement method and an absolute-value measurement method resulting in the measurement of the liquid for its dielectric coefficient and relative water content

characterized in that

- said measurement is repeated at two different temperatures in a so rapid succession that the water content of the liquid may be assumed to stay at least substantially constant.

2. Method according to claim 1, characterized in that the temperature dependence of the dielectric coefficient of an entirely dry liquid is determined by measuring essentially simultaneously the ε_r and temperature of the liquid at at least two temperatures.

3. Method according to claim 1 or 2, characterized in that said relative water content measurement is carried out using a capacitive sensor.

4. Method according to any one of foregoing claims, characterized in that changes in the results of water content measurement due to aging of the liquid are compensated for by virtue of using only the most recent data of the measurement history for the compensation for changes in the response of the measurement system.

PCT/ FI 00/ 00542
24 -08- 2001

5. Method according to any one of foregoing claims, characterized in that the aging of said liquid, advantageously oil, is indicated on the basis of changes in the value of ε_0.

6. Method according to any one of foregoing claims, characterized in that, in the measurement of relative water content, an auxiliary medium is used for absorbing thereto the water contained in the liquid under measurement.

7. Method according to claim 5, characterized in that said auxiliary medium is a thin-film polymer layer.

8. Method according to claim 5 or 6, characterized in that the water content of said auxiliary medium is determined by way of measuring its dielectric coefficient.

9. Apparatus for measurement of the water content of a liquid, said apparatus comprising one electrical sensor means (5, 6 or 1, 6) for measuring the water content of a liquid, which apparatus includes

- a second electrical sensor means (1, 6 or 5, 6) for measuring the water content of a liquid, said second sensor means (1, 6 or 5, 6) measuring a different parameter than that measured by said first electrical sensor means (5, 6 or 1, 6), said sensor means being such that one of them measures the properties of the liquid by a relative-value measurement method and the other by an absolute-value measurement method, whereby one sensor means (5, 6) is sensitive to changes in the dielectric coefficient and the other sensor means is sensitive to the relative water content,

characterized in that

– the sensor means adapted for measuring the relative water content contain an auxiliary medium capable of absorbing water contained in the liquid under measurement.

10. Apparatus according to claim 9, characterized in that said sensor means (5, 6) sensitive to changes in dielectric coefficient is formed by two interdigitated finger electrodes (5, 6).

11. Apparatus according to claim 9 or 10, characterized in that one electrode (6) of the sensor pair adapted to perform the measurement of dielectric coefficient also forms a part of the measurement electrode pair (1, 6) adapted to perform the measurement of the relative water content.

12. Apparatus according to claim 9, characterized in that the sensor means sensitive to changes in the dielectric coefficient is formed by a coaxial structure, wherein one electrode is formed by a center pin and the jacket has a net-like structure and is permeable to water.

13. Apparatus according to claim 12, characterized in that said auxiliary medium is a thin-film polymer layer.

14. Apparatus according to claim 12 or 13, characterized in that the apparatus contains means adapted to measure the dielectric coefficient of said auxiliary medium whereupon the relative water content of said auxiliary medium can be determined.

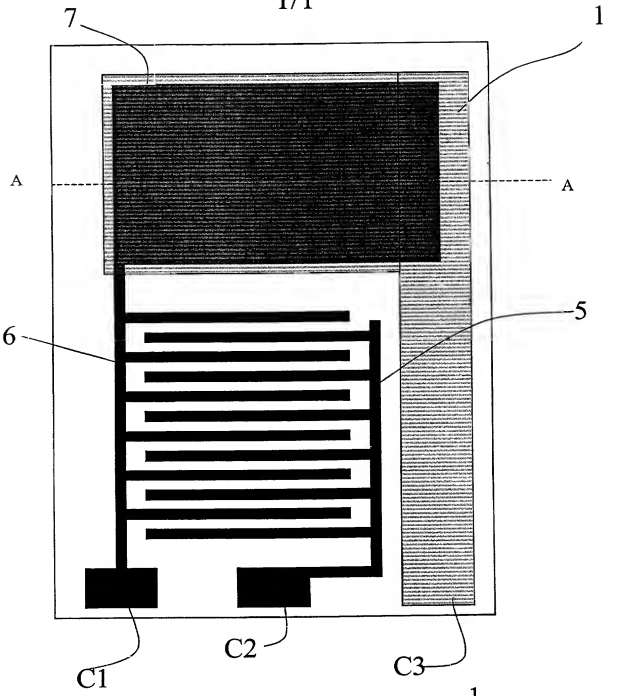

Fig. 1

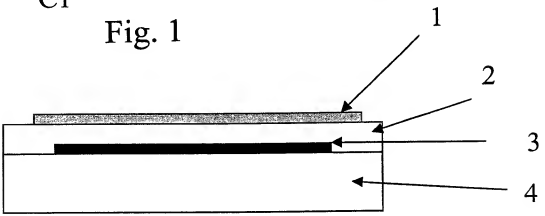

Fig. 2

VA7 81 US

BIRCH, STEWART, KOLASCH & BIRCH, LLP

PLEASE NOTE: YOU MUST COMPLETE THE FOLLOWING:

COMBINED DECLARATION AND POWER OF ATTORNEY

FOR PATENT AND DESIGN APPLICATIONS

ATTORNEY DOCKET NO. 365-525P

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title: Method and apparatus for measuring water content

Fill in Appropriate Information - For Use Without Specification Attached:

the specification of which is attached hereto. If not attached hereto,

the specification was filed on December 17, 2001 as

United States Application Number _____; and /or

the specification was filed on June 15, 2000 as PCT

International Application Number PCT/FI00/00542; and was

amended under PCT Article 19 on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Insert Priority Information: (if appropriate)

Prior Foreign Application(s)			Priority Claimed	
991391 (Number)	Finland (Country)	June 17, 1999 (Month/Day/Year Filed)	☒ Yes	☐ No
(Number)	(Country)	(Month/Day/Year Filed)	☐ Yes	☐ No
(Number)	(Country)	(Month/Day/Year Filed)	☐ Yes	☐ No
(Number)	(Country)	(Month/Day/Year Filed)	☐ Yes	☐ No
(Number)	(Country)	(Month/Day/Year Filed)	☐ Yes	☐ No

Insert Provisional Application(s): (if any)

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(Application Number) (Filing Date)

(Application Number) (Filing Date)

Insert Requested Information: (if appropriate)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More Than 12 Months (6 Months for Designs) Prior To The Filing Date of This Application:

Country	Application No.	Date of Filing (Month/Day/Year)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Insert Prior U.S. Application(s): (if any)

(Application Number) (Filing Date) (Status - patented, pending, abandoned)

(Application Number) (Filing Date) (Status - patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

Terrell C. Birch	(Reg. No. 19,382)	Raymond C. Stewart	(Reg. No. 21,066)
Joseph A. Kolasch	(Reg. No. 22,463)	James M. Slattery	(Reg. No. 28,380)
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PLEASE NOTE: YOU MUST COMPLETE THE FOLLOWING:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole Inventor: Insert Name of Inventor, Insert Date This Document is Signed (100)

GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Lars	Stormbom	[signature]	December 17, 2001

Insert Residence, Insert Citizenship

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Full Name of Fifth Inventor, if any see above

GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*

Residence (City, State & Country)	CITIZENSHIP

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* DATE OF SIGNATURE

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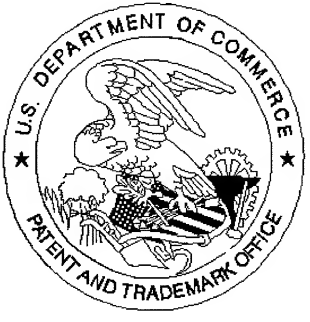

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